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is weakened by two considerations: First, the cutting teeth in the two genera are not homologous; second, the grinding series of molars, complete in Hypsiprymnus, is almost wanting in Thylacoleo. It evidently does not follow that because Hypsiprymnus is herbivorous Thylacoleo is so also. Professor Flower refers to the reduction of the molars in Thylacoleo as slightly complicating the problem, and concludes that the food of that animal may have been fruit or juicy roots, or even meat. It is difficult to imagine what kind of vegetable food could have been appropriated by such a dentition as that of Ptilodus and Thylacoleo. The sharp, thin, serrate or smooth edges are adapted for making cuts and dividing food into pieces. That these pieces were swallowed whole is indicated by the small size and weak structure of the molar teeth, which are not adapted for crushing or grinding anything but very small and soft bodies, It is not necessary to suppose that the dentition was used on the same kind of food in the large and the small species. In *Ptilodus mediævus* the diet may have consisted of small eggs which were picked up by the incisors and cut by the fourth premolars. In *Thylacoleo carnifex* it might have been larger eggs, as those of the crocodiles, or even the weaker living animals. The objection to the supposition that the food consisted of vegetables, is found in the necessity of swallowing the pieces without mastication. In case it should have been of a vegetable character the peculiar premolar teeth would cut off pieces of fruits and other soft parts as suggested by Professor Flower, but that these genera could have been herbivorous in the manner of the existing kangaroos, with their full series of molars in both jaws, is clearly an inadmissible supposition.

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VESTIGES OF GLACIAL MAN IN MINNESOTA.

BY MISS FRANC E. BABBITT.

(Continued from page 605, June number.)

THE notch quartzes hitherto examined have been differentiated by marked peculiarities of distribution, worth while to enumerate in this place.

First: as there were originally no quartzes afforded by the soil above the stratum, so there were none yielded by that lying immediately below; although it would naturally be expected that the floor of a primitive manufacturing site of this character would be permeated to a considerable depth with chips and other refuse. If in studying the quartz bed, for example, the hand, introduced within it horizontally, was carried at all above or below the superior or inferior plane of deposit, the fingers encountered no more fragments, except in spots where the layer had manifestly been thrown out of place by the growth of roots, and other recent agencies.

The uniform outline of the inferior plane of deposit, taken in connection with the total absence of chips and quartz fragments of every kind, from all explored portions of it, shows that these objects were spread out, primarily, upon a passably level surface of a compact, unyielding nature, such as might have been afforded by a firm sod, or by frozen ground. This peculiar feature of the situation, together with other facts hereafter to be stated, suggests the probability that the quartz deposit is somewhat in the nature of a *cache*, the nucleus of which was an ancient site of manufacture of stone implements. Appearances indicate that shortly after receiving position here, these quartzes were either solidly encased in ice or permanently sealed up in the modified drift at present superimposed upon them. Had it been otherwise, had the containing stratum, prior to its final inhumation, been long subjected to the climatic vicissitudes incident to the actual isothermal line of the region, results would no doubt have followed which, though differing possibly in degree, would certainly have been identical in kind with those now wrought out at the same point. Thus great thaws, soaking and softening rains, and, in short, local floods, however caused, could not have failed to affect exposed quartzes, to have effectually deranged and perhaps altogether broken up the original level of their bed, and to have let numbers of the involved objects down to varying depths in the underlying stone rubbish, while sweeping others away bodily to be distributed about the subjacent sands. It is desirable to emphasize the fact that the specified movements of soil are not merely a matter of speculation, but are the subject of direct observation. They are now in progress before our eyes from day to day, not only at the quartz bed, but likewise at every explored point in the vicinity, at which quartz products of disintegration find lodgment upon a sandy substratum. Let it be observed that the present is not a case of degradation going on upon a basis of rock affording permanent support to fragments detached. Even were it such, however, the quartzes would still have been subject to eolic influences whence we might look to see the successive products of ages of weathering widely disseminated and occupying different levels in the neighboring sand.

Second: it was a further peculiarity of the quartz layer that it did not thin out toward the west, in the direction of the river, as it should have done had its area been still intact. Contrawise, the quartzes extended in full thickness quite up to the extreme edge of the terrace-plain, where the deposit terminated abruptly in an obscuring layer of surface soil derived from the drift above. Previous to the inception of grading operations upon the notch, by which this ancient cache seems to have been nearly and perhaps quite obliterated, it was no infrequent thing, after heavy rains, to find quartzes, plainly extruded from the others, lying along the bottom-land west of their original bed.

The terrace consists properly of three sections, one above the other, which must have had their beginnings at three different periods. First, we have the lowest and oldest, comprising the body of till and drift below the quartzes; second, the quartz-yielding stratum itself; and third, and newest, the accumulations of modified drift above the latter. This classification is based on existing geological conditions, and formulates the necessary sequence of glacial events. It is, therefore, by no means an abstract or an arbitrary division. It is moreover not affected by the question whether or not the quartz layer is artificial in character. Even were it a proven fact that these fragments are wholly natural forms resulting from the wearing down of quartz veins, it would still be true that the quartzes must, at the time of their deposit, have occupied a surface now no longer existing as such, within the present plane of the middle section. The truncated condition of the western edge of the quartz layer, coinciding with that of the terrace-bank above it, points us back to a time when the two uppermost of these sections had as yet no existence, while the lower one, projected west of its present limits, was prepared to receive upon its surface, as in time it actually did receive, the quartzes now above it. The middle section, that is the stratum of quartzes, must in its turn have had a like westward prolongation. The superior section, deposited later still, participated in the same general extension. When the Mississippi finally withdrew permanently from the terrace-plain, and cutting out a lower bed for itself in the drift alluvium, formed the existing terrace-bank, it would naturally leave the quartz stratum what we find it to-day. That is, the western border having been cut off and swept away, the western limits of the remainder would preserve a general thickness uniform with that of the central portion, or nearly so.

During a copious and long-continued rainfall in the summer of 1881, the roadway leading through the notch was at one time washed out at its point of emergence and westward to a depth of four or five feet below the quartz stratum. The lower portion of the newly exposed surface was then seen to be stuck full of quartz chips intermingled with occasional quartz implements. These seemed to be vestiges of a former westward prolongation of the quartz-bearing stratum. An irregular block of quartz, from eight to twelve inches in dimension, was here found impacted in the stone rubbish at the top of the till. This is remarkable as being the only lump of quartz larger than a club-head ever encountered among the thousands taken from the place. The block was white, sharply angular, and wholly unwaterworn; it was associated with subangular and rounded stones which had no other visible unwaterworn fragments among them; and it had, still adhering to certain of its planes, foliations of some other mineral of so soft a nature that the blocks would inevitably have yielded to attrition had it ever been subjected thereto. Every appearance indicated that this was a mass which had been used to strike pieces from for further manipulation. It was imbedded among the quartz bits and implements before mentioned. These were strewn about in the utmost confusion, being wedged into the stone rubbish at every imaginable angle. Many of the latter specimens, unlike those from the stratum, were more or less defaced, having small, long bits nicked out of the surface. Among them were some few objects which belonged to stratum types, but which were nevertheless waterworn.

Third: certain of the quartzes of the stratum have been distinctly arranged upon the floor of deposit in little rudely assorted heaps or groups of objects of some one particular type. As a representative fact or two will very likely afford a clearer view of the case than can otherwise be had, a few illustrative details are offered here. During the autumn of 1879, upon the day when the existence of the quartz-bearing stratum was first definitely settled, I collected from it a half peck, or such a matter, of quartz pieces. Among these appeared a group of specimens numbering a dozen or more, which belonged to a type unknown to me at the time. The most finished implements of this shape have delicate, fragile edges formed by a single thin leaf of the quartz prolonged beyond the mass of the object in a series of irregular, minute notches. Further exploration of the site, continued up to the present time, has, so for as observed, failed to unearth a single specimen of the same class elsewhere. Whether we assume these small articles to be natural productions or artificial ones, or whether again we hold them to be natural forms more or less modified by the hand of man, there is no escaping the conviction that the grouping together of these and other like objects is wholly the work of intention. Previous to the discovery here narrated, I had more than once or twice chanced upon bunches of specimens of a common figure, lying in separate huddles in the sand at the edge of the stratum, and apparently just washed out of it.

Upon another occasion I found in my daily budget a small cluster of rude triangular points, quite unfashioned, as I thought, and averaging about an inch and a fourth, or a half, in length, by three-fourths of an inch in width. These being at first supposed to be unwrought figures, were thrown out as such. However, the persistent recurrence of identical forms in the day's yield eventually suggested a meaning of its own independent of the matter of workmanship. These bits were consequently put in comparison with fragments taken from waterworn quartz boulders from the edge of the Mississippi river, artificially broken up. It was found that certain of these boulders afforded by their fracture occasional specimens of the same general shape with those under study, while upon closer examination it was perceived that a considerable portion of the latter had at the base, upon opposite edges, two very small roundish notches, such as would be required for securing the object to a slender shaft, or handle, of wood or bone. None of the pieces seemed to have been flaked except at these notches, and if they had been otherwise worked at all, they had simply had their natural angles smoothed down by abrasion upon some stone.

Similar assortments of specimens having a common form have been brought to light in different portions of the stratum. Indeed, whenever I unearthed any individual object of comparatively large size, I very often, though by no means invariably, found it to be associated closely with others of kindred type. I have exhumed from this place groups of axe-like quartzes, of rasping stones, of broken implements, of long prong-shaped objects perhaps utilized by primitive man as weapons, and of other rudely fashioned things at the particular uses of which it is impossible to guess. However, there were also divers quartz shapes which were scattered about through the whole deposit, such as hammer-stones of different descriptions, sharp pieces adaptable as cutting-blades and a great many sharp and long splinters. Some of the latter have been more or less wrought, while others of ruder model appear to have been selected from accumulations of fractured quartz with reference to unknown industries.

The assorted arrangement of the stratum quartzes and the perfect preservation of even the very frailest of them are cognate facts, entirely congruous with the group of statements heretofore advanced. They show that this deposit did not suffer derangement before its final inhumation, nor at the period when the latter was in progress. They point strongly to the probability that these rude objects represent a palæolithic workshop and cache, the floor of which was shielded from disturbance by an icy envelop, or by the gentleness of movement of the encroaching waters, or by both of these causes combined, as is most likely. Were it otherwise possible for the quartz bed to be a product of disintegrating forces, it would still be incomprehensible that a stratum presenting the specific features of this, could have been exposed to the tumultuous action of air and frost during the time requisite for working out the degradation assumed. It is equally unintelligible that it has ever been attacked by the powerful currents of an onward-moving flood. These quartzes seem rather to have been submerged by some such gentle creeping action of water as we should expect in the case of a lake-like expansion produced by the backing up of water from below.

Fourth : the stratum quartzes comprise many distinct varieties of the mineral, distributed among a mass of pieces which have apparently been derived from the quartz-bearing slates of the vicinity. These fragments show strongly marked differences in opaqueness, color, hardness, cleavage and admixture of foreign matter. The mode of occurrence of the more erratic specimens is noteworthy, and leads to the inference that they may have been fashioned from drift boulders, numbers of them, indeed, having been evidently formed of waterworn pebbles. Objects shaped from some special variety of quartz not unfrequently present themselves in loose clusters, varying in number from two or three to a dozen or so pieces. Thus a single specimen of a tinted, mottled or otherwise distinguishable quality, has quite commonly been found associated with others of the same species of mineral. When one of these is of comparatively large size, the remaining objects are in many cases proportionally small, as if they had been shaped from fragments of the largest. In one part of the stratum I chanced upon several small quartzes which were, for the most part, longish splinters, and which had a peculiar sort of oölitic fracture closely resembling the grain of curly maple. I have never happened to find this sort of fracture in quartz from the Little Falls slates, though such may perhaps exist; but in studying a few boulders from the till, artificially broken up, I discovered a single waterworn mass, ten to twelve inches in diameter, having the same fracture. I afterward, at various times, encountered pieces of similar character at the stratum, three or four perhaps in a spot. These fragments have all, I believe, been inconsiderable in size. Now had even a small lump of this special sort of mineral been either disintegrated, or broken up upon the ground by human agency, a confused mass of bits of different sizes must naturally have resulted—which is not the fact. It is therefore not unlikely that the peculiarity of its cleavage unfitted this quality of quartz for being worked into large implements, but that in accidentally reducing small boulders of it, the quartz-workers selected from the splinters such bits as could in some way be turned to profit.

Professor Winchell says of terrace surfaces adjacent to the quartz stratum: "There is no point throughout the whole region round about where the slate conveying these quartz veins rises to the level of the surface of this plain so as to be within the range of transporting agencies, whether of the water of the river or of floating ice."

This statement concerning fragments diffused through the surface soil is, of course, not necessarily applicable to a plane a considerable depth below that surface. In fact, slate rock has been encountered a little distance east of the notch at a depth of only fourteen feet. It is certain also that exposures of slate veins have long since been eaten away by the Mississippi river on the west, and it is highly probable that all these once afforded the quartz-workers abundant supplies for industrial purposes. A great proportion of the pieces found here have actually been furnished from the quartz-yielding rock of the place. This being the case, however, it is still certain that the imbedded quartzes could not have been drifted to their present position by currents of water, nor by ice. The facts above cited forbid the possibility of such transportation; and, as shown, it is equally incredible that long continued disintegration in the open air should have left upon the fragments successively resulting, no trace of weathering nor of belonging to different planes of deposit. On the whole, the prehistoric record of glacial man at Little Falls, as understood at the present stage of investigation, may be briefly summed up as follows.

The quartz-working people flourished at a day when the upper division of the terrace-plain had not yet been spread out. As we have seen, the basal section of the terrace consists of till coated with stone rubbish and covered with a thin layer of soil. It was precisely here, upon this old surface, that the quartz-workers lived and pursued their pitiful labors. In the fulness of time this vanished folk, perhaps foreseeing the calamity of flood, posed upon the earthen floor adjoining their working-place, the quartz implements of the stratum. The impending disaster finally ensued; the movement of the muddy water inhuming these objects was so gentle as not to break up the original arrangement of assorted groups, nor yet mar the most delicate edges and points of the imbedded pieces. The deposit of quartzes was, at last, hermetically sealed. Except at the western edge it has thus remained, quite in *statu quo*, up to the present time; although there has been a constant tendency on the part of natural agencies to erode the drift above, and expose once more to the light of the sun the rude remains of this primitive race.

The floods at length abated, the waters of the swollen Mississippi wholly subsided; the river abandoned the terrace-plain altogether, it dug out a new bed for itself at a lower level. During the latter process, or subsequent thereto, the current washed out the western, or river, edge of the quartz deposit, and swept away all such products of man's labor as were at that time exposed to its action. The operating forces having been exerted upon the west of the present terrace-bank, it follows that only the eastern edge of the stratum remains to us, the western border being cut off and lost.

In finale, it is proper to reiterate the fact that the working hypothesis of the moment is one which the writer has been driven, in spite of preconceived notions, to adopt. All the internal evidence of the case, thus far elicited, harmonizes completely with the view enunciated, and with this view alone. The study here commenced is henceforth to be pursued along two distinct lines of investigation; one comprehending the drift surfaces of the region, the other the objects exhumed. The latter, or purely archæological phase of the subject, remains to be more fully developed at some future time; but it may be stated in this place that the quartzes of the cache are to the last degree primitive in their general types and particular forms, and in their style of workmanship.

A collection of something like a hundred of the quartz objects found in the notch at Little Falls has been submitted for examination to Professor Henry W. Haynes, of Boston, Mass., who writes of these specimens: "Some of them I believe to be implements; many are only chips struck off in shaping implements and refuse pieces left from such work; many are natural forms, and one or two rolled pebbles. I think that such objects as appear to be implements, in your collection, were managed by being held in the hand, and that early man had not advanced far enough to devise handles for his first rude implements. The masses of quartz were fitted for use by having most of their projections battered off by another stone; and if anything was required to soften the effect of the edges of stone upon the hand, it was a mass of moss, or leaves, or such object. I trace clearly upon your implements such a preparation of them for holding them in the hand. Many of yours bear evident marks of use in the worn condition of portions of their edges or of their points. When I look over the whole collection that I have made from different localities in New England of rude stone objects, mostly found at some depth below the surface, and compare their general appearance with that of my collection of Indian objects, I see plainly a great difference. Applying the same test to your quartzes, I see that they belong, as a whole, to the older class. That you have discovered a workshop of early man there is no doubt." Again he says: "I will merely repeat that I have not a shadow of a doubt that the 'quartzes' you have submitted to me are the product of an intentional breaking by the hand of man, and not the result of natural causes."

At the annual meeting of the American Association for the Advancement of Science held at Minneapolis, Minn., August, 1883, a small number of objects from the stratum at the notch, and from its western line of extension along the terrace-bank, were placed for study in the hands of Professor F. W. Putnam, curator of the Peabody Museum of Archæology at Cambridge, Mass. It is with peculiar satisfaction I find myself able to record his decision that a certain part of the quartzes examined by him have indubitably been fashioned by the hand of man. At the same meeting of scientists the following résumé of the glacial situation at Little Falls was contributed to this paper by Mr. Warren Upham, of the State geological survey, to whose personal researches and official reports we are largely indebted for the drift history of Minnesota. The geological data of the present article have, in great part, been drawn from notes kindly supplied for the purpose by Mr. Upham. Mr. Upham says:

"Two principal epochs of glaciation are clearly recognizable, in the earlier of which the ice-sheet extended somewhat beyond the Missouri river and nearly to the Ohio river, crossing the latter at Cincinnati, as recently proved by Professor Wright. All of Minnesota was, at that time, deeply covered by ice, excepting a tract next to the Mississippi river from Lake Pepin southeastward, which is included in a driftless area that extends 150 miles from north to south, and is 100 miles wide, lying mostly in Wisconsin. In the succeeding interglacial epoch there is good evidence that the ice was melted away upon this region, and that a temperate climate existed. Afterward came the second and last great glacial epoch, when an ice-sheet again covered nearly all of Minnesota and accumulated the terminal moraines that have been described in Wisconsin, Minnesota, Iowa and Dakota. The ice in this epoch did not extend so far south as before. Its border in southeastern Minnesota was some fifty miles back from the edge of the driftless area. In Iowa the most southern point that was covered by the ice of this last epoch is in the vicinity of Des Moines, about 300 miles north of its earlier limit. The part of southwestern Minnesota lying beyond the crest of the Coteau des Prairies escaped this later glaciation. The boundary of this ice-sheet, known by the course of its terminal moraine, entered Minnesota from Wisconsin across St. Croix lake; it crossed the Mississippi ten miles south of St. Paul, and thence extended about fifteen miles westerly to Crystal lake, in Dakota county, where the margin of the ice which moved southwestwardly from Lake Superior and northern Wisconsin met the margin of the ice which moved toward the south and southeast from the region of Lake Winnipeg and the Red River valley; from Crystal lake, the ice-border, at the east limit of the glacial current last mentioned, extended south through Rice, Steele, and Freeborn counties, into Iowa. Two currents of the ice-sheet, one coming from the northeast, the other from the northwest, were confluent, pushing against each other, upon an area reaching from Crystal lake and Lake Minnetonka 150 miles northwesterly to the Leaf hills, and even farther north to the lakes at the head of the Mississippi river. An area, or belt, extending thus, with a width varying from forty to a hundred miles, has a junction and overlapping of the till brought from the northwest and northeast, and series of morainic hills, which appear to prove that this region was wholly covered by the ice of the last glacial epoch; that the line of confluence of its currents was shifted in the latter part of this epoch far to the east upon a large district southeast of Stearns county, bringing till from the west over that from the east; and that during the final melting and disappearance of the ice, probably at times when this was interrupted by its reädvance upon part of the ground from which it had retreated, true terminal moraines were formed upon the sides of this belt which had been wholly ice-covered through most of this epoch. The inner moraine found in southern Minnesota and upon the Coteau des Prairies, the Leaf hills, and the very distinct series of morainic hills in Morrison county—one of which, accumulated by the ice-current from the northeast, lies close east of Little Falls—are of this kind, being terminal moraines formed at stages in the recession of the ice at the last glacial epoch.

"As soon as the ice had so far retreated as to uncover the present valley of the Mississippi river in Morrison county, the deposition of the modified drift, constituting the terrace-plain in which are found the quartz chippings, ensued, and continued during the retreat of the ice.[1] It seems very probable, that vegetation and animals followed close upon the retiring ice-border, and that even man, who lived near the Atlantic coast in this closing stage of the glacial period, as abundantly proved by recent discoveries in the drift-gravel near Trenton, N. J., may also have lived here at that time, and occupied the Mississippi valley directly after the ice-sheet retired. While the deposition of the valley-drift at Little Falls was still going forward, men may have lived there, and left, as the remnants of their manufacture of stone implements, the multitude of quartz fragments here described. By the continued deposition of the modified drift, lifting the river upon the surface of its glacial flood-plain, these quartz chips were deeply buried in that formation. The date of this valley-drift must be that of the retreat of the ice of the last glacial epoch, from whose melting were supplied both this sediment and the floods by which it was brought. The glacial flood-plain beneath whose surface the quartz fragments occur, was deposited in the same manner as additions are now made to the surface of the bottom-land; but the flooded condition of the river, by which this is done, was doubtless maintained through all the warm portion of the year, while the ice-sheet was being melted away upon the region of its head waters. In spring, autumn, and winter, or, in exceptional years, through much of the summer, it seems probable that the river was confined to a channel, being of insufficient volume to cover its flood-plain. At such a time this plain seems to have been the site of human habitations and industry, as shown in this paper.[1] After the complete disappearance of the ice from the basin of the Upper Mississippi, the supply of both water and sediment was so diminished that the river, from that time till now, has been occupied more in erosion than in deposition, and has cut its channel far below the level at which it then flowed, excavating and carrying to the Gulf of Mexico a great part of its glacial flood-plain, the remnants of which are seen as high terraces or plains upon each side of the river."

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[1] It is to be borne in mind as an important fact that the Little Falls quartz stratum lies *at the bottom* of the old flood-plain. Hence the quartz-workers must have occupied this spot at the point of time when its deposition began.

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EDITORS' TABLE.

EDITORS: A. S. PACKARD, JR., AND E. D. COPE.

—— The preservation of some herds of our larger game in the parks which are under the direction of the National Government is an object which has received the approval of various prominent persons from time to time. We believe that the constitution of the Yellowstone Park Commission contemplates the preservation of the game within its borders, but does not provide for the maintenance of herds of any size, or for any means of keeping them within the limits of the protected territory. It is asserted, however, that in point of fact the game is not better protected in the Yellowstone park than elsewhere.

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[1] Evidence is at present wanting that the quartz-workers revisited this field of operations between the abandonment of the quartz stratum and the spreading out of the uppermost portion of the terrace-plain.